Lung Nodule Classification Using Deep Features in CT Images

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June 5th, 2015
Outline

- Why?
  - Motivation
- What?
  - Proposed Approach
- How?
  - Exp. Setup
- So, What?
  - Future Work
Why?

- Lung cancer results in **17%** of total cancer related deaths.
- **Early diagnosis** required as it is harder to contain in later stages.
- **Burden** on doctors for early diagnosis.
- **Untapped data** is now available to build effective computer aided diagnosis (CAD) systems.

**Goal:** second opinion!
Proposed Approach

- Build an effective CAD system to classify annotated nodules as malignant or benign using *deep* features extracted from autoencoder and binary decision tree as classifier.

**Figure**: Proposed system flow diagram
LIDC-IDRI dataset
- Thoracic CT images of 1010 patients
- Diagnostic data for 157 patients available (ground truth)
  - Ratings: 0-Unknown, 1-benign, 2-Primary malignant, 3-metastatic
- Annotations provided!
- Nodule size: 3 mm to 30 mm

Figure: Annotations provided by four different radiologists
CAD system Design: Autoencoder

- Design:
  - Encoder
  - Decoder
Let

- input be $f(x^i) \in [0, 1]^d$
- latent space $y \in [0, 1]^d$
- $\phi$ be non linear function

$$y = \phi(Wf(x^i) + b)$$ (1)

Reconstruction:

$$f(x^i)' = \phi(W'y + b')$$ (2)

Error minimization:

$$\min_{W,b} \sum_{i=1}^{n} \| f(x^i)' - f(x^i) \|^2$$ (3)
Figure: Stacked autoencoder formation
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Our Design

- 3 Hidden layers
- Layer size 200,100,200
- Iteration set: 30
- Batch size: 400
- Feature extraction at 3rd hidden layer
Experimental Setup

- Data: 4303 Instances (4323 nodules)
  - Obtained from diagnostic data
  - all provided annotation considered
  - Rating: 1: benign & 0,2,3: malignant
- Feature extraction: features are extracted from 4th layer (3rd hidden layer)
  - 200 dim. vector
- Training:
  - 90% of 4303 Instances
  - 10-fold cross validation

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CRV conference, 2015
10 fold cross validation avg.:
- Accuracy: 75.01
- Sensitivity: 83.35
- FP/patient: 0.39

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<tr>
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<th>Deep Features</th>
<th>Belief Decision Trees$^1$</th>
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<tr>
<td>Accuracy</td>
<td>75.01%</td>
<td>68.66%</td>
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Figure: significant visual similarities between the annotated nodules in (a,d), (b,e) and (c,f), making it very difficult to differentiate between such nodules during the classification process.
So, What?
Future Work

- different deep architectures (e.g. CNN) & more hidden layers i.e. *very deep* networks (16-19 layers)
- combination of features
- STAPLE
- SPIE lung nodule classification challenge
- Automatic nodule detection
Thank you for listening!

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